GPM Profile Classification and Surface Snowfall Algorithm

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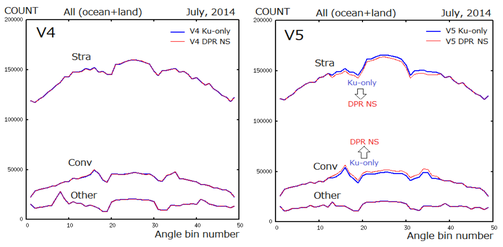
Abstract

Dual-frequency profile classification module of GPM (Global Precipitation Measurement) DPR (Dual-frequency Precipitation Radar) has gone through expensive validations using both TRMM (Tropical Rainfall Measurement Mission) radar products and ground based radar system since launch and shows promising results. In version 5, we have developed an algorithm to identify surface snowfall based on dual-frequency radar observations. Here, we present validation cases showing snow algorithm results with NPOL radar, airborne radar and ground truth during OLYMPEX field campaign. Other validation cases with NEXRAD radar and CSU-CHILL radar are also illustrated.

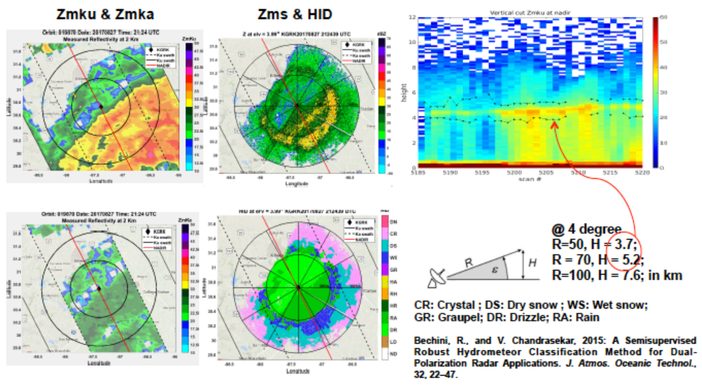
Comparison of rain type for dual-frequency method and Ku-only method in V5 after bug fixing



- In V4, Ku-only type counts and dual-frequency type counts are almost the same.
- In V5, the difference between ku-only type counts and dual-frequency type counts becomes appreciable because of dual frequency processing. The dual-frequency types would be more reliable than the Ku-only types in V5.

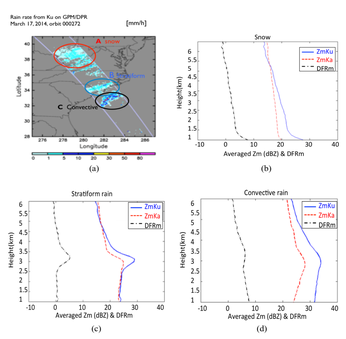
Hurricane Harvey

DPR overpass # 19870 on 08/27/2017 at 21:24 UTC
with KGRK, Fort Hood, Texas



Bechini, R., and V. Chandrasekar, 2015: A Semisupervised Robust Hydrometeor Classification Method for Dual-Polarization Radar Applications. *J. Atmos. Oceanic Technol.*, 32, 22–47.

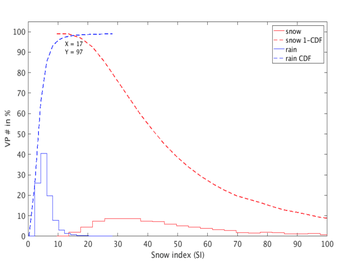
Surface Snowfall Detection Algorithm

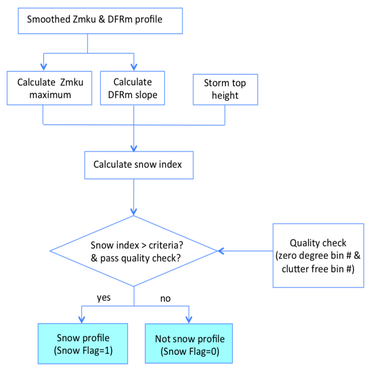


Features: (i) DFRm slope is appreciable for snow compared to stratiform rain; (ii) maximum of reflectivity for snow is less than 30 dBZ, while for convective rain is around 35-40 dBZ; (iii) storm top height for snow is lower than convective rain in a general sense. Combining these features, we design a snow index to perform effective separation between snowfall and rain (includes stratiform and convective).

(a) GPM DPR overpass of rainfall rate on March 17, 2014 (#000272). Circled A, B and C represents snow, stratiform rain, and convective rain. (b) Averaged reflectivity profiles as well as dual-frequency ratio profile for snow. (c) Same as (b) for stratiform rain. (d) Same as (b) for convective rain.

$$SI = \frac{mean(abs(DFRm_{slope}))}{Zmku_{max} * Storm\_top\_height} \quad (1)$$





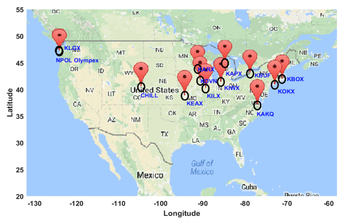
Large scale study of snow index using GPM DPR profiles. Histogram of snow index for rain (blue) and snow (red). Blue dashed curve is the cumulative density function (CDF) for rain. Red dashed curve is 1-CDF for snow.

The details of the algorithm can be found in Le et al. (2017).

Ground Validation using dual-polarization radars

Validation cases:

NEXRAD radar: 14 cases with 11 radars.(3 new cases with 3 new radar: KAPX, KAKQ, KARX)
NPOL radar: 3 cases (Olympex).
CSU CHILL radar: 1 case.



US map with ground radar locations that snow validation has been performed

Radar name	Date	GPM DPR orbit #
NPOL	2015-12-03 2015-11-14 2015-11-17	010019 009722 009773
CSU-CHILL	2016-04-16	012119
KLGX	2015-01-04 2015-03-22 2015-11-14	004839 006038 009722
KDVN	2014-12-22 2015-11-21	004638 009828
KEAX	2015-01-31	005263
KIWX	2015-03-23	006052
KBUF	2015-03-14	005908
KILX	2014-12-22	004638
KOKX	2015-01-09	004914
KBOX	2015-03-14	005913
KAPX	2016-02-25	011319
KAKQ	2016-02-05	011011
KARX	2016-03-24	011755

Validation during OLYMPEX:

Validation of the algorithm is performed with NPOL radar, APR3 observation as well as ground truth during OLYMPEX campaign from November 2015 through February 2016.

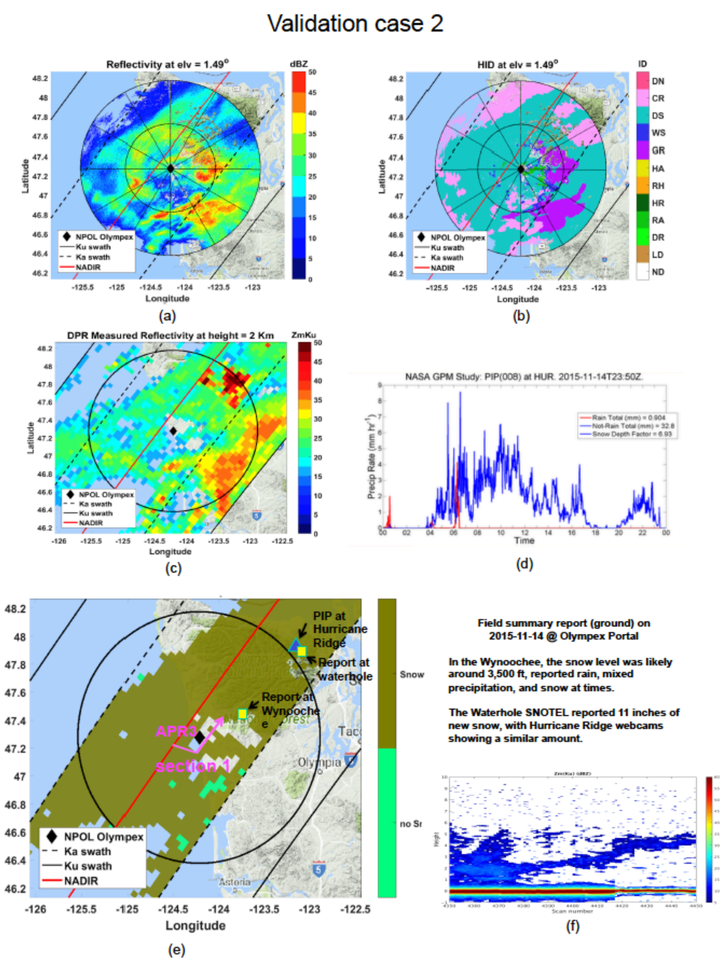
Validation case 1

Snow observed on Dec 3rd, 2015 during OLYMPEX. (a) NPOL reflectivity at 0.48 degree. Dashed/solid straight lines are boundaries of DPR inner/outer swath. Black circle is the 100 km range of the NPOL radar. (b) shows the hydrometeor type (or HID) for the scan. (c) is Ku- band reflectivity at 2km for DPR overpass #10019. (d) The surface snowfall flag. Snow presents at northeast of the scan. (e) PIP plots at Hurricane Ridge showing mixture of snow and rain.

Field summary report (ground) on 2015-12-03@ Olympex Portal

- **As of 1400 UTC, the Wynoochee trailer has recorded 144 mm of rain since 00 UTC.**

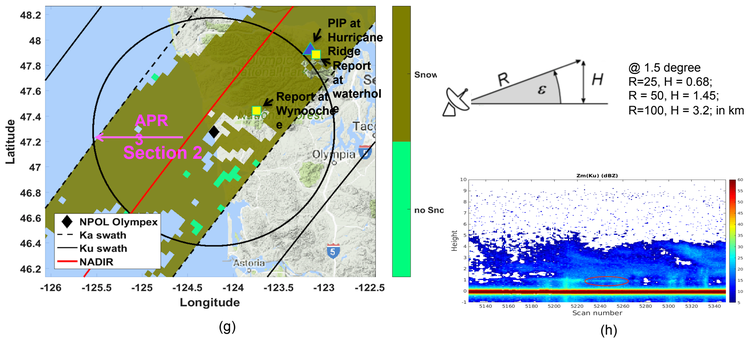
Validation case 2



Field summary report (ground) on 2015-11-14 @ Olympex Portal

In the Wynoochee, the snow level was likely around 3,500 ft, reported rain, mixed precipitation, and snow at times.

The Waterhole SNOTEL reported 11 inches of new snow, with Hurricane Ridge webcams showing a similar amount.

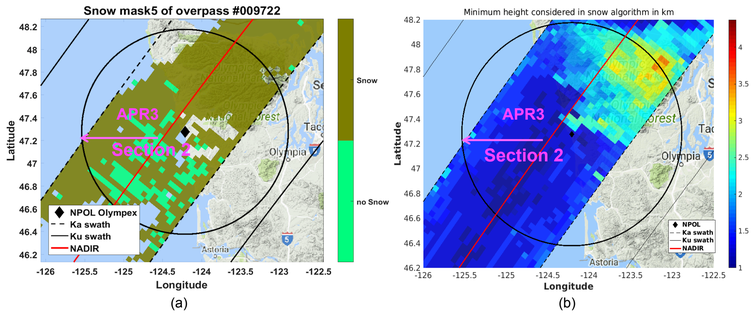


@ 1.5 degree
R=25, H = 0.68;
R = 50, H = 1.45;
R=100, H = 3.2; in km

Snow event observed by both NPOL radar and DPR on Nov 14th, 2015 in WA. (a) NPOL reflectivity at 1.48 degree. (b) illustrates hydrometeor type identified. (c) DPR Ku band measurement at 2 km. (d) PIP plots at Hurricane Ridge showing snow. (e) surface snowfall flag with locations of PIP image and ground report location. APR3 path of section 1 is also shown.(f) APR3 observation of Zmku at section 1 shown in (e). (g) Same as (e) but shows airborne observation at section 2. (h) APR3 observation of Zmku at section 2.

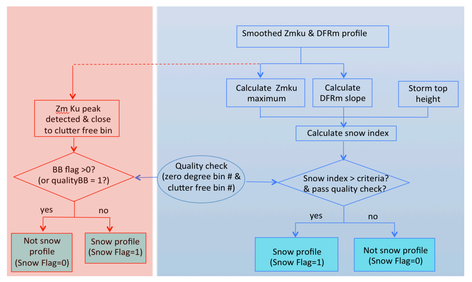
Possible modification to the algorithm when melting could possibly happen at very low altitude (within several bins from clutter free bin)

- include bright band flag or bright band quality flag.

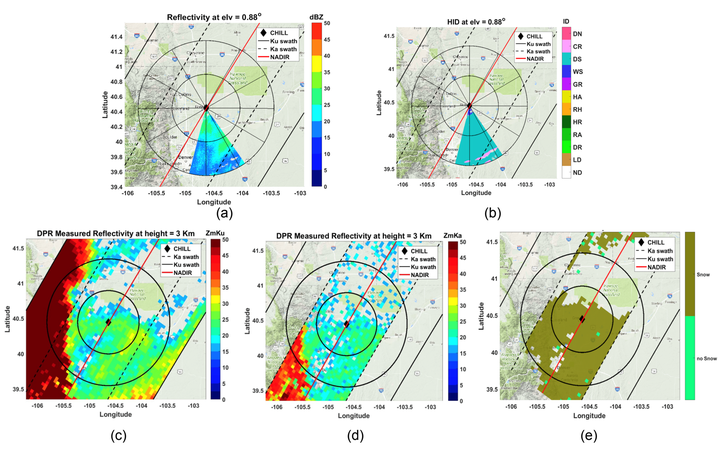


(a) Snow mask if include bright band flag for low bright band cases. (b) Minimum height considered in the snow algorithm.

Possible modification in algorithm flowchart



Validation with CSU-CHILL radar during snow:



Another snow event observed by both CSU CHILL radar and DPR (orbit # 12119) on APR 16th, 2016 in CO a) CHILL reflectivity at 0.88 degree. (b) illustrates hydrometeor type identified. (c) And (d) are Ku- Ka- band reflectivity at 2km for DPR. The surface snowfall identification algorithm is applied to the DPR inner swath and the snow flag is shown in (e)

SUMMARY

➢In V5, the difference between ku-only type counts and dual-frequency type counts becomes appreciable because of dual frequency processing after bugs are fixed. The dual-frequency types would be more reliable than the Ku-only types in V5.

➢Melting layer top and bottom from V5 are cross validated with ground radar during hurricane Harvey and Irma and show good comparisons.

➢Surface snowfall detection algorithm has been validated with different kinds of ground radars including NEXRAD, NPOL and CSU-CHILL. During OLYMPEX campaign, snow algorithm has been cross validated with NPOL radar, APR3 observation and ground truth. Satisfactory comparisons are achieved. Possible algorithm modifications are needed for low bright band cases.

REFERENCE

M. Le, V. Chandrasekar and S. Biswas, An Algorithm to Identify Surface Snowfall from GPM DPR Observations: Geoscience and Remote Sensing, IEEE Transactions, Vol. PP, issue 99, pp. 1-13, 2017.

Bechini, R., and V. Chandrasekar, 2015: A Semisupervised Robust Hydrometeor Classification Method for Dual-Polarization Radar Applications. J. Atmos. Oceanic Technol., 32, 22–47.

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